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ECOLOGICAL STUDIES ON *CARDIOCONDYLA ECTOPIA* SNELLING (HYMENOPTERA: FORMICIDAE) IN SOUTHERN CALIFORNIA.[1]

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Abstract.—At this location, *Cardiocondyla ectopia* Snelling is a largely diurnal species which foraged throughout the year when ambient temperatures exceeded 18.9° C. Its major food source was nectar from sweet alyssum flowers, *Lobularia maritima* Desvaux. It preyed on insects, particularly small caterpillars, and it was also a scavenger. It nested in small cavities in mortar, cracks and expansion joints in concrete, and in soil. A colony was excavated from which 322 ants were retrieved. This represented the largest nest population ever recorded for a *Cardiocondyla* species. A number of behavioral strategies, in addition to a potent repellent chemical, probably allow *C. ectopia* to live in sympatry and synchrony with *Linepithema humile* (Mayr).

Key Words.—Insecta, Formicidae, *Cardiocondyla ectopia*, foraging, food sources, nest sites, nest population, coexistence, *Linepithema humile*, *Lobularia maritima*

Cardiocondyla ectopia Snelling was described in 1974 from specimens taken from Orange and Los Angeles counties, California (Snelling 1974). This species was also reported from Arizona (MacKay 1995). Although this species was recorded from southern California, it has been rarely collected from this area. A survey of urban ants of California yielded 30 species but *C. ectopia* was not recorded (Knight & Rust 1990.) However, I collected this species on several occasions around structures in the cities of Downey and Long Beach (Los Angeles County), and Montclair and Ontario (San Bernardino County). This ant has been overlooked by structural pest control operators in southern California probably because of its small size, small colonies, cryptic nests, absence of trailing behavior, and its apparent inability to invade structures.

All current biological information available on *C. ectopia* is contained in Creighton & Snelling (1974). Herein I provide additional information on *C. ectopia* foraging behavior, food resource utilization, nest sites, nest population, and its coexistence with the Argentine ant, *Linepithema humile* (Mayr).

MATERIALS AND METHODS

I observed six colonies of *C. ectopia* located on my property in Ontario, San Bernardino County, California. Periodic observations, encompassing an hour or more at a time, began in January 1995 and continued through May 1996 as time permitted. On weekends, intermittent observations began as early as 08:00 h and continued for several hours at a time until 23:00 h. Most of the observations recorded here were made with an OptiVisor optical glass binocular magnifier (Donegan Optical Company, Kansas City, Missouri). From these observations, information was gathered on foraging behavior, food resource utilization, nest location, coexistence with the Argentine ant, *Linepithema humile* (Mayr), and

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chemical defense strategy. On 25 Nov 1995, a colony of *C. ectopia* was excavated and the number of ants retrieved was recorded.

Results and Discussions

Foraging Behavior.—Cardiocondyla ectopia is a largely diurnal species. Above ground activity of this ant is governed by temperature. Foraging activity in July 1972 was reported to begin when the ambient temperature ranges from 18.9 to 20 °C (Creighton & Snelling 1974). When asphalt temperature reached 26.1 °C foragers were no longer using the exposed surfaces (Creighton & Snelling 1974). I observed surface activity of this ant during the third and fourth weeks of December 1995 when the concrete temperature was 15.6 °C (recorded with a surface temperature thermometer - Sybron Taylor Products, Arden, North Carolina). This activity was observed as early as 08:40 h when several workers and four alates were found around the nest entrance area. These ants were lethargic and a few appeared to be moribund. As the temperature increased ant activity increased. They may have been induced to emerge from this nest in an expansion joint in the slab because bright sunlight was shining directly on this area. Creighton & Snelling (1974) recorded some surface activity of this ant as late as 19:25 h in July 1972. During the last week of December 1995, foraging activity on sweet alyssum flowers, *Lobularia maritima* Desvaux was observed as late as 16:30 h. On 19 May 1996, foraging on these flowers was observed at 20:10 h. Some ant activity around the nest area was observed at 20:26 h on 19 May 1996 when observations had to be made with a flashlight as it was too dark to see these ants. Ant activities were observed as late as 23:05 h in July and August 1996 at unusual food sources such as dog food and soda. At this location, *C. ectopia* foraged throughout the year whenever temperatures were conducive to above ground activity.

Cardiocondyla ectopia searched its foraging territory in a random manner. Individuals were found traversing areas as much as 6 m away from the nest. The colonies I observed foraged mostly on nectar from flowers of sweet alyssum. This landscape annual produces tiny white four-petaled flowers which are borne in clusters and the flowers emit a honeylike fragrance. Once a plant was located, *C. ectopia* foragers returned to this resource many times to exploit it. I observed numerous individuals from two colonies travelling directly to a clump of sweet alyssum located 3 m away from the nests. Tandem running and recruitment to a food source occurs in the genus *Cardiocondyla* (Wilson 1959a, Creighton & Snelling 1974). *Cardiocondyla ectopia* also exhibited this behavior, but it was not common. Associative learning appeared to be present in this species as these ants repeatedly returned to a productive floral food source by different routes over many days. I observed foragers returning to a location where I had removed a clump of flowers for up to two h after the plants were gone.

Foragers of *C. ectopia* readily ascended various herbaceous plants and explored their surfaces. Many of these plants did not have flowers and it appeared that the ants were searching for other food sources, probably, extrafloral nectaries, glandular plant exudates, honeydew, live and dead insects, etc.

On 26 Nov 1995, four foragers of *C. ectopia* were observed searching the surfaces of a small bean plant. The leaves of this plant exhibited typical caterpillar

damage and it may have been the source of some of the first instar caterpillars retrieved from foragers returning to their nests.

On 26 Nov 1995, five dead *C. ectopia* workers were found at different locations on the stem of a small tomato plant, *Lycopersicon esculentum* Miller. Microscopic examination of these ants revealed no obvious bodily injury. It is possible that these ants were killed by toxic glandular exudates from this plant. Glandular exudates, particularly sucrose and glucose esters from solanaceous plants such as tomato and tobacco, have been reported to immobilize small herbivores, inhibit and/or deter feeding, or to be toxic (Kennedy & Yamamoto 1979, Gregory et al. 1986, King et al. 1990).

During the first three weeks of November 1995, several foragers of *C. ectopia* were observed ascending and descending a cardboard receptacle that was 0.6 m in height and was located about 0.6 m from their nest. This container held empty soda cans for recycling and *C. ectopia* workers were observed on the lids of several cans feeding on soda remnants. On 13 Aug 1996 as many as 75 ants were counted on this soda can. This is an example of an opportunistic ant species exploiting a man-made food resource.

Food Resource Utilization.—Information on food resource utilization by members of the genus *Cardiocondyla* is scarce. *Cardiocondyla venustula* Wheeler is reported to be a scavenger (Wilson 1959a); *C. emeryi* Forel is thought to be omnivorous (Creighton & Snelling 1974); *C. wroughtoni* Forel is reported to be a predator (Lupo & Gerling 1984); and *C. ectopia* has been observed taking nectar from *Chamaesyce serpens* Small (Creighton & Snelling 1974).

At this location, ants from all *C. ectopia* colonies fed primarily on nectar from flowers of sweet alyssum. Twelve foragers were recorded from one plant and as many as three workers were found on one tiny flower. Foragers often spent considerable time on flowers of this plant.

Cardiocondyla ectopia also exhibited predatory behavior. The following live insects were retrieved from individual foragers returning to their nests: two first instar caterpillars, one second instar caterpillar, one first instar geometrid larva, an unknown small legless larva, and a small aphid. When freed from the mandibles of the foragers, the caterpillars attempted to crawl away. On 25 Dec 1995, one forager was observed attempting to remove a second instar caterpillar from a sweet alyssum plant. It was experiencing great difficulty in doing so because the caterpillar was holding on to the plant. Finally, the ant and its quarry fell off the plant. Once on the ground, the ant was more successful in carrying the caterpillar especially when it grasped the caterpillar at about its midsection. Even when the prey was on the ground, the ant was not able to transport it more than a few centimeters at a time. Occasionally, it left the prey and ran about the area in a "frenzied" manner perhaps attempting to locate another nestmate which it could possibly recruit to this food resource.

At this site, *C. ectopia* also functioned as a scavenger. The following dried, dead arthropods were retrieved from foragers returning to their nests: a small caterpillar, a cast larval skin, three small flies, a thrips, a drain fly (family Psychodidae) two collembolans, one earwig nymph, a chironomid midge, and a spiderling.

In August 1994, while evaluating commercial ant baits for Argentine ant control, small amounts of Drax Ant Kill Gel—a sucrose/orthoboric acid ant gel bait,

(Waterbury Companies, Waterbury, Connecticut) were dispensed in short pieces of plastic straws and placed at various locations on the study site. *Cardiocondyla ectopia* foragers discovered this bait at one location and fed on it.

The fact that this ant fed on soda and on a sugar-based ant bait indicates that, if accessible in nature, *C. ectopia* will probably feed at extrafloral nectaries. On 13 Jul 1996, *C. ectopia* were observed feeding on honeydew produced by aphids on cowpea plants at this location. Members of the genus *Cardiocondyla* have been reported to feed on honeydew (Smith 1944).

Nest Location.—Around human habitation *C. ectopia* utilized various sites to establish its nests. At least six nests existed on this property during these investigations. Two nests were located in cavities in mortar at the edge of bricks along the side of the concrete driveway. A third nest was located in soil on the south side of the house next to a concrete walkway. The fourth nest was found at the southeast corner of the building in an expansion joint where the concrete walkway met the foundation of the structure. The fifth nest was located in a crack in a concrete walkway at the southeast corner of the house. The sixth nest was located in soil at the edge of a concrete walkway leading to the front door of the structure. Only one of the nest entrances on this property was ever surrounded by a pile of debris as reported elsewhere (Creighton & Snelling 1974). However, nests of *C. ectopia* which were located in bare soil on a residential property in Montclair, California, were always surrounded by piles of miscellaneous materials. The presence of debris around a nest entrance is probably influenced by soil type, nest location, and type of food utilized.

On two occasions, when attempting to pinpoint nest entrances, the entry points were inadvertently enlarged by the author. The ants immediately closed off the entrances. They quickly gathered whatever materials were available from around the nest entrances and began piling them into the opening. Examples of materials used were small pieces of stucco, dirt, sand grains, small rocks, small pieces of mortar and concrete, flower petals of alyssum, and tiny pieces of grass clippings.

Nest Population.—Reported colony size of some members of the genus *Cardiocondyla* are as follows: *C. venustula*—probably no more than 100 or 200 workers (Wilson 1959a); *C. nuda*—two dealated queens and 38 workers (Creighton & Snelling 1974); *C. paradoxa*—50 adults (Wilson 1959b); *C. thoracica*—70 adults (Wilson 1959b); *C. ectopia*—eight dealate females, two alate females, 75 workers and 2 males. Immatures were not counted but they were estimated at 55 larvae and 15 pupae (Creighton & Snelling 1974).

A total of 322 ants were recovered from an excavated colony of *C. ectopia* representing the largest number ever recorded for a *Cardiocondyla* species. Castes retrieved included 72 alate females, 13 dealate females, two males and 233 workers. Immatures were not counted. These numbers are considerably higher than the numbers previously recorded for a colony of *C. ectopia* (Creighton & Snelling 1974).

Coexistence with the Argentine Ant.—The Argentine ant *Linepithema humile* (Mayr), is a notoriously aggressive species which can negatively impact the biodiversity of ecosystems (Smith 1936, Haskins 1939, Michener 1942, Haskins & Haskins 1965, Smith 1965, Wilson & Taylor 1967, Crowell 1968, Fluker & Beardsley 1970, Ebeling 1975, Erickson 1975, Lieberburg et al. 1975, Ward 1987, Gulmahamad 1995). However, *C. ectopia* was observed by the author coexisting

with the Argentine ant at four different geographical locations in southern California. At one site, it was surviving in a nest with the entrance located only 8 cm from a nest of the Argentine ant and only 3 cm from an active trail of this species.

Cardiocondyla ectopia appears to employ a number of behavioral strategies to survive in association with the pugnacious Argentine ant. Some examples of these behavioral strategies might be (1) it forages individually and seldom recruits to food sources by tandem running, thus maintaining a low profile presence in sympatric and synchronous situations, (2) although it is omnivorous, its major food source is nectar from certain flowers, and its predaceous and scavenging activities do not appear to bring it in conflict with the Argentine ant as far as food resource utilization is concerned. No agonistic interactions were ever observed between the two species at any food source during these observations, (3) it maintains small colony populations and thus there are fewer opportunities for conflict among individuals of the two species, (4) it utilizes small, cryptic nest entrances, (5) only a small number of foragers of *C. ectopia* are usually above ground at a given time thus the potential for conflicts between the two species is much reduced, (6) foragers of *C. ectopia* enter and leave the nest singly, thus workers do not draw attention to the nest entrance (7) alates leave the nest singly and at intervals, thus there is no aggregation of swarmers at the nest entrance to draw unwanted attention to the nest, and (8) during favorable temperature and daylight conditions, workers emerging from a nest crawl away from the nest entrance immediately thus there is no congregation of ants at or around the nest area.

All of the above strategies probably enables *C. ectopia* to maintain a low profile existence in a hostile territory.

Chemical Defense Strategy of C. ectopia.—Ants are known to use chemicals as defense weapons when threatened by other species (Blum 1981, Hermann & Blum 1981, Buschinger & Maschwitz 1984, Hermann 1984). Members of the genus *Cardiocondyla* are known to use chemicals to protect themselves from aggressive and carnivorous species (Creighton & Snelling 1974). These authors reported that *C. emeryi* often nest in close proximity to colonies of *Solenopsis geminata* (F.) and *Pheidole dentata* Mayr in Texas. They observed minor workers of *P. dentata* responding in a near panic manner in the presence of workers of *C. emeryi*. They postulated that the use of repellent chemicals may explain the nesting of *C. emeryi* close to other aggressive ants species. Creighton & Snelling (1974) also noted that Argentine ant workers often behaved in a very erratic fashion when they encountered workers of *C. ectopia*.

I observed *C. ectopia* using a chemical to defend itself against the Argentine ant on many occasions. When this material was released, it elicited a dramatic frenzied and agitated running behavior in an affected Argentine ant. Shortly thereafter, the recipient was often vigorously engaged in cleaning its eyes, antennae, and mouthparts with its forelegs. This material is of abdominal origin as crushed abdomens of *C. ectopia* elicited frenzied and agitated running behavior when touched on the heads of conspecifics as well as workers of *L. humile*. The repellent material elicited the most dramatic reaction when applied to the head of the aggressor. Chance encounters between individual ants of these species often did not result in the use of this repellent chemical. At least twelve interspecific contacts between these ants were observed which did not result in the use of the repellent

material. In these situations, the individuals involved briefly examined each other and then separated. This is a beneficial strategy because production of defensive chemicals represents a drain of resources which dictates prudent use. Possession of a potent repellent chemical does not always insure self preservation in a continuous hostile territory. On two occasions, individual *C. ectopia* workers inadvertently wandered into well established trails of the Argentine ant. In these situations, *L. humile* workers attacked and dispatched these individuals with mandibular cuts. Two encounters between individuals of *C. ectopia* and *L. humile* resulted in the loss of an antenna by *C. ectopia.*

A combination of the various behavioral strategies described earlier in this paper and the prudent use of a repellent chemical probably enables *C. ectopia* to survive in disturbed urban environments around structures in southern California which are dominated by the Argentine ant.

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